CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY

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FAULT EVALUATION REPORT FER-224
GILLEM, BIG CRACK, AND RELATED FAULTS
WESTERN MODOC, AND EASTERN SISKIYOU COUNTIES,CALIFORNIA

by

William A. Bryant
Associate Geologist
November 20, 1990
(Revised March 14, 1991)

Division of Mines and Geology
630 Bercut Drive
Sacramento, CA 95814

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INTRODUCTION

Potentially active faults in the Tule Lake study area of western Modoc County and eastern Siskiyou County that are evaluated in this Fault Evaluation Report (FER) include the Gillem, Big Crack, Hovey Point, Crumes Lake, Fleener Place, and Saddle Blanket Flat faults (Figure 1). With the exception of the Gillem and Big Crack faults, none of the faults evaluated in this FER have previously been named. Informal names are proposed in this FER in order to facilitate discussion. The Tule Lake study area is located in the Medicine Lake, Mt. Dome, and Tulelake 15-minute quadrangles (Figure 1).

Faults in the Tule Lake study area are evaluated as part of a statewide effort to evaluate faults for recency of activity. Those faults determined to be sufficiently active (Holocene) and well-defined are zoned by the State Geologist as directed by the Alquist-Priolo Special Studies Zones Act of 1972 (Hart, 1988).

This fault evaluation consists of literature review, reconnaissance aerial photographic interpretation, and very limited field checking. Time limitations precluded a thorough study of the area with respect to both detailed air photo interpretation and field observations.

SUMMARY OF AVAILABLE DATA

The Tule Lake study area is located in the Modoc Plateau geomorphic province. The Modoc Plateau is characterized by extensive volcanic rocks of late Tertiary and Quaternary age that are displaced by many north to northwest-trending normal faults. East-west directed extension characterizes the most recent stress regime in the study area, which has resulted in north-trending normal faults.

Topography in the study area ranges from the flat surface of Tule Lake to the moderately rugged relief of the Gillem Bluff escarpment. The southern part of the study area is located along the northern flank of Medicine Lake volcano. Elevations in the study area range from 1228 meters at the Tule Lake basin to 2410 meters at the summit of Mt. Hoffman just south of the study area. Development in the study area is relatively low. The town of Tule Lake is the largest settlement and is located in the north central part of the study area (Figure 1). Agriculture (farming and cattle grazing) is the principal activity in the study area.

Rocks in the study area are predominately volcanic flow and pyroclastic rocks of late Tertiary to Holocene age (Gay and Aune, 1958; Donnelly-Nolan and Champion, 1987). Unconsolidated Quaternary deposits, which are sparse throughout most of the study area, include Pleistocene and Holocene lacustrine deposits of Tule Lake and isolated, minor glacial outwash deposits (Gay and Aune, 1958; Donnelly-Nolan and Champion, 1987).

Mapping by Gay and Aune (1958; unpublished field maps), Burnett (unpublished air photo interpretation), and Donnelly-Nolan and Champion (1987) will be evaluated in this FER.

Aerial photographic interpretation by this writer of faults in the Tule Lake study area was accomplished using aerial photographs from the U.S. Department of Agriculture (BUW, 1955; DDC, 1955). Selected fault traces interpreted from aerial photographs by this writer were mapped where geomorphic features were well-defined or where faults mapped by others seemed to be mislocated due to the small scale of the original mapping. Field mapping was very brief, consisting of one-half day in October checking strands of the Gillem fault.

GILLEM FAULT

Literature Review

The Gillem fault, a 30 km-long north-trending normal fault with down-to-the-east vertical displacement, is a classic example of a tilted fault block (Figures 1, 2a and 2b). This fault is the easternmost of four west-tilted fault blocks with down-to-the-east vertical displacement (Photo 1). Cumulative vertical displacement along the fault is not known. However, the east-facing scarp is as high as 295 meters at its northern end, indicating a minimum of 295 meters of vertical displacement. The Gillem fault has previously been mapped by Gay and Aune (1958; unpublished field maps) and Donnelly-Nolan and Champion (1987).

Gay and Aune (1958; unpublished field maps) mapped the southernmost reach of the Gillem fault as offsetting late Quaternary volcanic rocks (Figure 2a). The fault north of Lava Beds National Monument mapped by Gay and Aune juxtaposes Tertiary volcanic rocks against Holocene (Recent) lacustrine deposits (Figure 2a).

Donnelly-Nolan and Champion (1987) mapped the Gillem fault in detail within Lava Beds National Monument (Figures 2a and 2b). They show the fault as offsetting late Pleistocene volcanic rocks, principally the Mammoth Crater basalt. This flow unit has not been radiometrically dated. However, Donnelly-Nolan and Champion (1987) reported that the flow is magnetically normal, indicating that it is younger than the Brunhes-Matuyama magnetic reversal (730 ka). A gravel unit mapped by Donnelly-Nolan and Champion just to the east of Mammoth Crater overlies the Mammoth Crater basalt (locality 1, Figure 2b). This gravel unit was interpreted to be a glacial outwash deposit possibly equivalent to late Tioga glacial stage of the Sierra Nevada (J.Donnelly-Nolan, p.c., 11-8-90). Thus, the age of the Mammoth Crater Basalt is thought to be approximately 40 ka (J. Donnelly-Nolan, p.c. 11-8-90). She also stated that no soils stratigraphic work has been done in the monument.

Donnelly-Nolan and Champion (1987) mapped the Devils Homestead Basalt as concealing the Gillem fault at Fleener Chimneys (locality 2, Figure 2a). To the north of Fleener Chimneys they mapped a solid line fault between Pleistocene volcanic rocks and the Devils Homestead basalt (Figure 2a). It is not clear if they intended to depict the fault as offsetting the Devils Homestead basalt or to show it as having flowed against the existing scarp.

The age of the Devils Homestead Basalt is critical in determining the recency of movement along the Gillem fault. Donnelly-Nolan and Champion (1987) did not report a radiometric age for the Devils Garden Basalt, but assumed that the flow unit was mid- to early Holocene. It is definitely older than the Callahan flow, which has been radiocarbon-dated at 1110 ± 60 ybp (Donnelly-Nolan and Champion, 1987). The Devils Homestead basalt flow is now thought to have erupted about 10,500 ybp. This is based on paleomagnetic work by Donnelly-Nolan and others (in press; Donnelly-Nolan, p.c., 11-8-90) and correlation with other radiometrically dated flow units from Medicine Lake volcano.

Donnelly-Nolan and Champion (1987) reported that displacement along the Gillem fault diminishes to the south. At the northern end of Lava Beds National Monument, displacement along the fault is at least 160 meters. At Fleener Chimneys the Gillem fault scarp is about 30 meters high (locality 2, Figure 2a). South of Fleener Chimneys, the Gillem fault offsets Mammoth Crater basalt a maximum of about 15 m.

The Gillem fault is expressed as a zone of fissures in Mammoth Crater basalt at its southernmost end and dies out before reaching the late Holocene Callahan flow. Donnelly-Nolan (p.c., 11-8-90) stated that the Gillem fault lacks evidence of recent activity along its northern extent.

The Gillem fault is inferred to have a late Quaternary slip-rate of 0.15 mm/yr to 0.38 mm/yr. This is based on the 15 meter offset of the Mammoth Crater basalt. The lower value is based on an assumed age of 100,000 years for the Mammoth Crater basalt; the larger value is based on the assumption that the Mammoth Crater basalt is about 40 ka.

Aerial Photographic Interpretation and Field Observations

The Gillem fault is a moderately to locally well-defined normal fault, based on air photo interpretation and brief field checking by this writer (Figures 2a and 2b). Traces of the fault mapped by Gay and Aune were locally verified by this writer. However, the fault mapped by Gay and Aune is generally only an approximation of the fault. Interpretation by this writer did not verify the offset of lake deposits along the fault north of the Lava Beds National Monument that could be interpreted from Gay and Aune's mapping (Figure 2a).

Mapping by Donnelly-Nolan and Champion (1987) was generally verified by this writer, based on air photo interpretation and limited field inspection (Figures 2a and 2b). The mapping in the monument is generally of very high quality and traces are well-located. I did not verify the offset of early Holocene Devils Homestead basalt in the vicinity of Fleener Chimneys (Figure 2a). The Devils Homestead basalt flowed against the existing Gillem fault scarp, but subsequent movement along the fault has not occurred.

I concur with the statement by Donnelly-Nolan (p.c., 11-8-90): the Gillem fault lacks geomorphic evidence of recent faulting along most of its trace north of the monument. The fault is generally delineated by an east-facing scarp in Tertiary volcanic bedrock. The scarp, which is locally up to 295 meters high, is covered by talus along approximately the lower one third of the slope. This talus slope is unbroken, suggesting either that the fault has not been active during the Holocene, or that the fault has a very low Holocene slip-rate. The scarp is relatively undissected along most of its length. However, no significant drainages cross the scarp and its westward tilt directs most runoff away from the scarp.

Because there are relatively few drainages incised into the scarp, alluvial fans are very sparse and are not useful for evaluating fault recency. One exception is at the very northern end of the fault where two drainages have incised into the scarp (locality 3, Figure 2a). Here both the drainages and alluvial fans lack evidence of recent vertical displacement.

A younger flow unit within the late Pleistocene Mammoth Crater Basalt flowed across an approximately 5 m high scarp at locality 4, based on field observations by this writer (Figure 2b; Photo 2). The predominant sense of displacement is extension and is delineated by well-defined troughs. Vertical displacement of the younger flow unit is minimal across the Gillem fault. These well-defined troughs developed in very blocky basalt. It is not clear how young the rubble is within troughs. The troughs in the younger flow unit aline with fissures along the principal trace of the Gillem fault to the north and south. However, unfilled fissures are not common along most of trace of the Gillem fault (Figures 2a and 2b).

Partly filled fissures are located near the northern boundary of Lava Beds National Monument (locality 5, Figure 2a). Some unfilled fissures just south of this location are probably related to the early Holocene Devils Homestead flow and are probably "slump scarps" as described by Sharpe (1938). Fissures were not observed along the Gillem fault south of Fleener Chimneys until just north of locality 4 (Figure 2b) . The fissures continue to the south and are the principal feature delineating the Gillem fault south of locality 6 (Figure 2b).

The general absence of fissures along most of the Gillem fault, the lack of offset of the early Holocene Devils Homestead basalt (Donnelly-Nolan and others, in press), and the lack of additional geomorphic features indicative of Holocene normal faulting indicate that the Gillem fault has not ruptured the surface during Holocene time. It is quite possible that the fissures that delineate the fault south of Fleener Chimneys are more closely related to volcanic processes. However, a close link between volcanic and tectonic processes may occur in this area (Donnelly-Nolan and others, in press).

FAULTS WEST OF THE GILLEM FAULT

Literature Review

Two major faults and one minor fault occur west of the Gillem fault and probably are structurally related (Figure 2a). These faults are characterized by down-to-the-east normal displacement and are delineated by east-facing scarps in volcanic bedrock. The faults previously have not been named. Informal names proposed in this FER are the Fleener Place and Crumes Lake faults (Figures 1, 2a). The short, westernmost fault mapped by Gay and Aune (unpublished field maps) will be referred to as Fault A (Figure 2a).

The Fleener Place and Crumes Lake faults were mapped by Gay and Aune (1958; unpublished field maps) (Figure 2a). Donnelly-Nolan and Champion (1987) mapped the southern extent of the Fleener Place fault in the Lava Beds National Monument (Figures 2a and 2b).

Gay and Aune mapped Quaternary volcanic rocks offset by these north-trending faults (Figure 2a). However, the offset volcanic rocks may be correlative with basalt of Devils Garden, a late Miocene to Pliocene volcanic unit of the Devils Garden Plateau (McKee and others, 1983). Fault A mapped by Gay and Aune extends into Holocene (Recent) lake deposits (locality 7, Figure 2a).

Donnelly-Nolan and Champion (1987) mapped the southern extent of the Fleener Place fault in Lava Beds National Monument (Figures 2a and 2b). This fault offsets Pleistocene andesite of Whitney Butte. It is assumed that the flow unit is late Pleistocene in age.

Additional minor faults west of the Crumes Lake fault were mapped by Gay and Aune (Figure 2a). These faults offset pre-Quaternary volcanic rocks and were not evaluated in detail.

Aerial Photographic Interpretation

Faults west of the Gillem fault mapped by Gay and Aune were generally verified with respect to location by this writer, although significant differences in detail exist (Figure 2a). The faults are delineated by moderately to locally well-defined, east-facing scarps in resistant volcanic flows. Numerous shallow depressions and associated ponded alluvium were observed along the base of scarps defining the Fleener Place and Crumes Lake faults (Figure 2a). Other closed depressions were observed away from the principal faults and generally are associated with scarps in volcanic bedrock that range from sharp to subdued. Most of the ponded alluvium along the Fleener Place and Crumes Lake faults is probably due to the westward tilting of the individual fault blocks, resulting in an undrained internal drainage system. It can be argued that the closed depressions and ponded alluvium at the base of the east-facing scarps indicate recent displacement along the Fleener Place and Crumes Lake faults. This is probably true, but the lack of offset of latest Pleistocene to Holocene shorelines along the northern extent of the faults and the drastic reduction in offset of late Pleistocene volcanic rocks to the south suggest minimal to no Holocene displacement.

The Crumes Lake fault is characterized by numerous large, active landslides along the east-facing scarp in volcanic bedrock (Figure 2a). It is probable that these landslides are due to weak beds that underlie resistant volcanic flow rocks, such as fine-grained lacustrine deposits indicated by the presence of light-toned exposures in the scarp face. Landsliding due to seismic shaking seems unlikely because other large fault scarps in the area do not have these numerous landslides. These landslides obscure most geomorphic evidence of recent faulting that may exist along the base of the east-facing scarp, although the closed depressions suggest recent faulting.

Additional faults not mapped by Gay and Aune occur on the tilted fault blocks bounded by the Gillem, Fleener Place, and Crumes Lake faults (Figure 2a). These faults are minor and generally trend east-west. Partly filled fissures were observed along the Fleener Place and Crumes Lake faults, along previously unmapped, minor west-trending faults, and, locally, paralleling slope contours in the vicinity of Summit Lake (localities 8-10, Figure 2a).

Fault A extended into Recent (Holocene) (?) lake deposits as mapped by Gay and Aune (Figure 2a). The extension of Fault A is delineated by a vague tonal lineament. Additional geomorphic evidence of recent faulting was not observed.

BIG CRACK FAULT

The Big Crack fault, located almost entirely within Lava Beds National Monument, is an 8 km long north-trending fault first mapped by Gay and Aune (1958, unpublished field maps) (Figure 2c). The fault mapped by Gay and Aune offsets late Quaternary volcanic rocks but does not extend into Holocene lake deposits at its northern end (Figure 2c).

Donnelly-Nolan and Champion (1987) mapped the Big Crack fault within the boundaries of Lava Beds National Monument (Figure 2c). Mapping by Donnelly-Nolan and Champion (1987) and Gay and Aune agrees very well with respect to location. Donnelly-Nolan and Champion (1987) mapped late Pleistocene Mammoth Crater basalt as the youngest unit offset by the Big Crack fault. (Refer to the Gillem fault discussion for the approximately 40 ka age of the Mammoth Crater basalt.)

Aerial Photographic Interpretation

The Big Crack fault is a well-defined north-trending extensional feature, based on air photo interpretation by this writer (Figure 2c). The Big Crack fault mapped by Gay and Aune and Donnelly-Nolan and Champion (1987) was verified by this writer. However, the fault does not extend quite as far south as mapped by Gay and Aune (Figure 2c).

The Big Crack fault is delineated by a narrow zone of sub-parallel, somewhat anastomosing fissures. The fissures are mostly un-filled. There is no systematic sense to the pattern of fissures (i.e. left- or right-stepping). Evidence of lateral offset was not observed, based on numerous constructional flow features that are continuous across the Big Crack fault (e.g. localities 11 and 12, Figure 2c). There may be a very minor component of vertical displacement along the fault, but the dominant sense of displacement is extension. A break in slope at locality 13 may indicate minor down-to-the-west vertical displacement. However, an alternative explanation is that the break in slope may be more closely related to constructional flow features.

The southern end of the Big Crack fault is concealed by a younger late Pleistocene lava flow (basaltic andesite of Three Sisters) (Figure 2c). It could be argued that the fault dies out just north of this younger flow. However, partly filled fissures extend to the margin of the younger flow. This flow margin is very irregular and does not completely overlie the older basalt of The Panhandle (Donnelly-Nolan and Champion, 1987). Where patches of the older flow are exposed, partly filled fissures that align with the Big Crack fault were observed by this writer, based on air photo interpretation. This indicates that the fissures were partly to completely buried by the basalt of Three Sisters.

FAULTS ON THE WEST SIDE OF THE DEVILS GARDEN PLATEAU

Literature Review

Several generally north-trending normal faults are located at the eastern edge of the Tule Lake study area, including a 23 km long, previously unnamed fault informally referred to in this FER as the Saddle Blanket Flat fault (Figure 2c). These faults were mapped by Gay and Aune (1958; unpublished field maps) and Burnett (unpublished air photo interpretation). Gay and Aune mapped these faults as offsetting volcanic rocks ranging in age from Tertiary to late Quaternary. The basalt of Devils Garden mapped throughout most of the Devils Garden Plateau, thought to be a young Quaternary unit by Gay and Aune, has been shown to be late Miocene to Pliocene in age (McKee and others, 1983). No alluvial unit was mapped as offset by these north-trending normal faults.

Mapping by Burnett consisted of air photo interpretation only (Figure 2c). No geologic units were mapped and scarp directions were not shown. Mapping by Burnett generally agrees with mapping by Gay and Aune with respect to location of fault traces (Figure 2c). Burnett did not map faults west of the shoreline of Tule Lake or Highway 139.

Aerial Photographic Interpretation

Faults in the western Devils Garden Plateau are generally delineated by west-facing scarps in resistant basalt (Figure 2c). The majority of faults mapped by Gay and Aune and Burnett were verified with respect to location by this writer. However, most of these north to north-northwest trending normal faults are only moderately defined in volcanic bedrock and lack geomorphic evidence of late Quaternary offset. For example, most of the scarps in basalt are rounded and degraded. A cinder cone erupted along a fault at locality 14. This cinder cone is eroded and lacks evidence of offset subsequent to its emplacement.

The Saddle Blanket Flat fault (informally named in this FER) is moderately to locally well-defined and is delineated by a west-facing scarp in basalt (Figure 2c). Filled fissures were observed on air photos near the southern end of the fault (locality 15) and modified troughs near the base of the scarp were observed at localities 16 and 17 (Figure 2c). The troughs near the base of the scarp do not seem to be young features and may be in part erosional. Minor drainages that cross the northern part of the fault are not offset, indicating a lack of recent activity. A possible left-step in this fault connects with a west-facing scarp near the southern end of the Tule Lake study area (locality 19, Figure 2c). This fault lacks specific geomorphic features indicative of latest Pleistocene to Holocene offset.

HOVEY POINT AND RELATED FAULTS

Literature Review

Several minor faults were mapped by Donnelly-Nolan and Champion (1987) west of the Gillem fault and east of the Big Crack fault (Figures 2a and 2c). These faults trend north to north-northeast and offset Pleistocene volcanic rocks (Hovey Point and Canby Bay basalt). These minor faults were not mapped by Gay and Aune. The longest fault (informally referred to as the Hovey Point fault) mapped by Donnelly-Nolan and Champion (1987) is about 5.5 km long.

Aerial Photographic Interpretation

The faults mapped by Donnelly-Nolan and Champion (1987) between the Gillem and Big Crack faults were verified by this writer, based on air photo interpretation (Figures 2a and 2c). The faults are delineated by fissures that are both unfilled and partly filled. Faults in this area lack evidence of lateral and vertical displacement.

The Hovey Point fault mapped by Donnelly-Nolan and Champion (1987) is delineated by a poorly defined east-facing scarp at its northern end (Figure 2a). The scarp has been modified by wave erosion during previous highstands of Tule Lake. South of the east-facing scarp the fault is delineated by partly filled fissures. Here the fault changes to a more southwesterly trend.

The Hovey Point fault can be extended farther south than mapped by Donnelly-Nolan and Champion, based on air photo interpretation by this writer (Figure 2a). The fault/fissures trend toward Ross Chimneys, a late Holocene series of spatter vents (locality 18, Figure 2a). The late Holocene basalt flow from Ross Chimneys seems to conceal the fissures. It was not possible to discern whether or not the flow filled some of the fissures without field verification. Additional fissures were observed by this writer south of Ross Chimneys. These fissures may connect with Black Crater, another source for a minor Holocene basalt flow. Additional faults/fissures in this area are minor and generally do not extend for more than 1 km.

SEISMICITY

The study area is characterized by a paucity of seismic activity. A and B quality epicenters in the Tule Lake study area have not been recorded (CIT, 1985) and only one epicenter location of lesser quality has been recorded. One event of magnitude 3.0 to 4.4 occurred about in the vicinity of Mt. Dome, located at the western side of the study area (Figure 2a).

CONCLUSIONS

GILLEM FAULT

The Gillem fault is a 30 km-long, north-trending normal fault with at least 295 meters of down-to-the-east vertical displacement (Figures 1, 2a and 2b). Mapping by Donnelly-Nolan and Champion (1987) was verified by this writer with respect to location (Figures 2a and 2b). Mapping by Gay and Aune (1958) is generalized.

Traces of the Gillem fault locally are well-defined and are indicative of late Pleistocene normal displacement (Figures 2a and 2b). The southern half of the fault is moderately well to well-defined, but the northern extent of the fault is moderately to poorly defined (Figures 2a and 2b). Late Pleistocene Mammoth Crater basalt is offset vertically, indicated by an approximately 15 meter high scarp at locality 4 (Figure 2b). A younger flow unit within the Mammoth Crater basalt flowed across the scarp at locality 4. Displacement of this younger flow unit is delineated by troughs aligned with the Gillem fault, but vertical offset is minimal. Thus, significant vertical displacement along the Gillem fault in latest Pleistocene to Holocene time is lacking, or is very minor and possibly distributive.

The basalt of Devils Homestead is an early Holocene basalt flow (approximately 10,500 ybp, Donnelly-Nolan and others, in press). This flow erupted along and locally conceals the Gillem fault (locality 2, Figure 2a). This is the most compelling evidence for a lack of Holocene fault rupture along the Gillem fault.

FAULTS WEST OF GILLEM FAULT

Three faults are located west of and are structurally similar to the Gillem fault (Figures 1, 2a, and 2b). These faults, informally referred to (from east to west) as the Fleener Place, Crumes Lake, and Fault A faults, are characterized by down-to-the-east normal displacement. The faults are moderately to locally well-defined and offset late Pleistocene andesite of Whitney Butte (Donnelly-Nolan and Champion, 1987). These faults are associated with closed depressions and ponded alluvium at the base of the east-facing scarps, indicating recent offset of possible Holocene age. However, the closed depressions and ponded alluvium may not be mandatory of Holocene displacement. There are other closed depressions on the offset geomorphic surface, most of which are associated with minor scarps in volcanic bedrock that range from well-defined to poorly defined. In addition, the Fleener Place, Crumes Lake, and Fault A faults do not offset latest Pleistocene to Holocene shorelines and lacustrine deposits to the north. To the south, displacement diminishes and late Pleistocene (?) volcanic rocks are only slightly offset, suggesting minimal to no Holocene displacement. However, precise dating of volcanic rocks and geomorphic surfaces is generally lacking in the study area. Thus, minor, possibly distributive Holocene displacement cannot be ruled out.

BIG CRACK FAULT

The Big Crack fault is an 8 km long, north-trending fault characterized almost entirely by extensional displacement and is delineated by linear, unfilled fissures (Figures 1, 2c). Constructional features of late Pleistocene lava flows are not offset laterally, although there may be a minor amount of vertical offset (localities 11 - 13, Figure 2c). Mapping by Gay and Aune (1958) and Donnelly-Nolan and Champion (1987) was generally verified by this writer, based on air photo interpretation. The southern extent of the Big Crack fault is concealed by a younger late Pleistocene lava flow unit, indicating a lack of Holocene displacement (Figure 2c).

FAULTS ON THE WEST SIDE OF DEVILS GARDEN PLATEAU

Several north-trending normal faults are located on the western side of the Devils Garden Plateau, including a 23 km long fault with down-to-the-west normal displacement informally referred to in this FER as the Saddle Blanket Flat fault (Figures 1 and 2c). These faults offset basalt of the Devils Garden, a late Miocene to Pliocene volcanic unit found throughout the Devils Garden Plateau (McKee and others, 1983). Except for the Saddle Blanket Flat fault, faults in this area are moderately defined and lack geomorphic evidence of recent faulting (Figure 2c). The Saddle Blanket Flat fault is delineated by a locally well-defined scarp in resistant basalt. Two modified troughs near the base of the scarp are suggestive of recent faulting, but may be erosional. Drainages that cross the scarp are incised into the resistant basalt and lack evidence of recent uplift, indicating a lack of Holocene vertical displacement (Figure 2c).

HOVEY POINT AND RELATED FAULTS

Several minor north to north-east-trending faults mapped by Donnelly-Nolan and Champion (1987) are located between the Gillem and Big Crack faults (Figures 2a and 2c). These faults, which offset late Pleistocene volcanic rocks, are delineated by linear, unfilled to partly filled fissures. A weathered, wave-modified (?) scarp was mapped by Donnelly-Nolan and Champion at the northern end of what is referred to in this FER as the Hovey Point fault (Figure 2a). Other than this poorly defined scarp, the faults/fissures lack evidence of vertical or lateral displacement.

The apparent association of the Hovey Point fault/fissures with both Ross Chimneys and Black Crater (Holocene spatter vents) indicates that the fissures may be more closely related to volcanic processes, such as the fissures associated with dike emplacement on the western flank of Medicine Lake volcano described by Fink and Pollard (1983).

RECOMMENDATIONS

Recommendations for zoning faults for special studies are based on the criteria of "sufficiently active" and "well-defined" (Hart, 1988).

GILLEM FAULT

Do not zone for special studies traces of the Gillem fault. This fault is not sufficiently active.

FAULTS WEST OF GILLEM FAULT

Do not zone for special studies faults west of the Gillem fault. These faults do not appear to be sufficiently active.

BIG CRACK FAULT

Do not zone for special studies the Big Crack fault. This fault is not sufficiently active.

FAULTS ON THE WEST SIDE OF DEVILS GARDEN PLATEAU

Do not zone for special studies faults on the west side of the Devils Garden Plateau, including the Saddle Blanket Flat fault. These faults are neither sufficiently active nor well-defined.

HOVEY POINT AND RELATED FAULTS

Do not zone for special studies. These features may not be sufficiently active and may not be tectonic in origin.

Reviewed & approved
Earl W. Hart
CEG 935
3/22/91

William A. Bryant

William A. Bryant
Associate Geologist
R.G. #3717
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U.S. Department of Agriculture, 1955, Aerial photographs DDC 1P- 42 to 47; 2P- 11 to 18; 3P- 16 to 23, 91 to 99, 112 to 131, 200 to 211; 14P- 4 to 13, 30 to 33; 21P- 117 to 123, black and white, vertical, approximate scale 1:23,000.

Photo 1 (to FER-224). The Gillem fault is delineated by the prominent east-facing scarp in the background (open arrow); view north. Additional east-facing scarps (arrows) delineate the Fleener Place (west of the Gillem fault) and Crumes Lake faults. The basalt of Mammoth Crater, a late Pleistocene flow that is found throughout Lava Beds National Monument, crops out in the foreground.

Photo 2 (to FER-224). A 5-meter high, east-facing scarp in late Pleistocene basalt of Mammoth Crater delineates the southern Gillem fault (foreground); view north. A younger flow unit within the basalt of Mammoth Crater flowed across this scarp. The Gillem fault is expressed in this younger flow unit principally by a linear trough (arrow) that aligns with fissures near the top of the 5-meter high scarp both north and south of the flow unit.